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THESIS

COMBINED ARMS STAFF TRAINER
FEASIBILITY STUDY FOR USE IN THE NPS
C3 CURRICULUM

by

Patrick J. Kanewske

June, 1993

Principal Advisor: Michael Sovereign
Associate Advisor: Wayne Hughes

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The object of this thesis is to explore the possibility of the Combined Arms Staff Trainer's (CAST) use in the Command, Control, and Communications (C3) Curriculum. War gaming in the United States Armed Forces and at the Naval Postgraduate School is explored. The CAST system is described in its present form as used by the United States Marine Corps, and how the system can be manipulated to suit the needs of the C3 Curriculum. The feasibility of implementing the proposed system changes to satisfy required knowledge elements in the C3 Curriculum is explored. Who will use the CAST, and how the CAST can be facilitated at NPS is also discussed.

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COMBINED ARMS STAFF TRAINER FEASIBILITY STUDY FOR USE IN THE NPS C3 CURRICULUM

by

Patrick J. Kanewske
Captain, United States Marine Corps
B.S., United States Naval Academy, 1981

Submitted in partial fulfillment
of the requirements for the degree of

MASTER OF SCIENCE IN SYSTEMS TECHNOLOGY

from the

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June 1993

Author: [redacted]
Patrick J. Kanewske

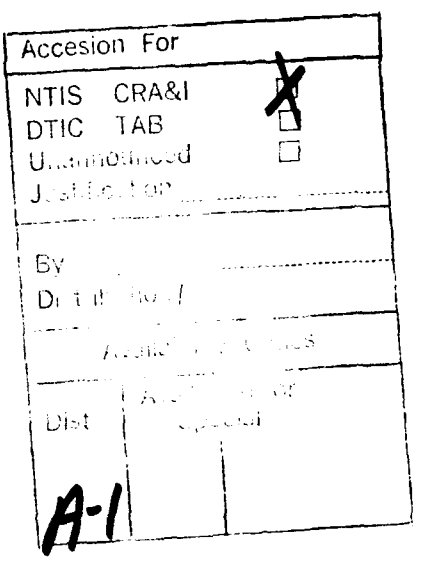
Approved by: [redacted]
Michael Sovereign, Principal Advisor

[redacted]
Wayne P. Hughes, Associate Advisor

[redacted]
Paul H. Moose, Chairman
Command, Control, and Communications Academic Group

ABSTRACT

The objective of this thesis is to explore the possibility of the Combined Arms Staff Trainer's (CAST) use in the Command, Control, and Communications (C3) Curriculum. War gaming in the United States Armed Forces and at the Naval Postgraduate School is explored. The CAST system is described in its present form as used by the United States Marine Corps, and how the system can be manipulated to suit the needs of the C3 Curriculum. The feasibility of implementing the proposed system changes to satisfy required knowledge elements in the C3 Curriculum is explored. Who will use the CAST, and how the CAST can be facilitated at NPS is also discussed.



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I. INTRODUCTION

A. BACKGROUND

1. Area of Research

This thesis examines the need for introducing a force-on-force aggregate war game into the Joint Command, Control, and Communications (C3) Curriculum at the Naval Postgraduate School (NPS), Monterey, CA. The thesis will explore: The function of war gaming in the military in general and at NPS; the Combined Arms Staff Trainer (CAST) system description, capabilities, and measures of effectiveness (MOEs); the need for operational awareness in the C3 curriculum; CAST as a C3 trainer at NPS; how to implement CAST into the C3 curriculum; and facilitating CAST at NPS.

2. Research Questions

This thesis will analyze the feasibility of implementing the CAST into the C3 Curriculum. The primary research questions are: (1) does the C3 Curriculum need a war gaming system to help each student realize operational awareness of C3 problems and (2) is the CAST System a suitable tool to help the student attain this realization? Additional qu stions are, can the CAST System be scaled down to meet the C3 Curriculum's needs, are the facilities available at NPS to house the system, are the support personnel available to

operate the system, and is the money available to fund the system?

3. Discussion

At NPS, graduate students come from varied services, backgrounds, and levels of operational expertise. Many students have never been operationally involved with the military. The C3 Curriculum requires a certain level of understanding in the operational arena. Students must be aware of the C3 problems inherent with military operations. The Combined Arms Staff Trainer can facilitate a better understanding of operational C3 problems.

The Southwest Research Institute (SWRI), San Antonio, Texas has built six enhanced CAST systems for the Marine Corps, one at each of the three Marine Divisions, one at 29 Palms, CA, one at Quantico, VA, and one at Kaneohe Bay, HI. The system utilizes a Marine Expeditionary Brigade (MEB) scenario to exercise the user's ability to command units in battle, and control forces and equipment.[Ref 1] CAST employs a unique communications system that functionally imitates doctrinal communications networks. The enhanced CAST system can be scaled down to fit the needs of a small group, 35 students for instance. CAST has the potential to be extremely beneficial to the C3 student in helping them realize the inherent C3 problems associated with operating in a combat environment. The system is capable of being modified to run

a number of scenarios, while prompting the student to make basic decisions effecting the outcome of the game. An in-depth knowledge of combined arms warfare doctrine is not necessary.

B. SCOPE

1. Scope of the Thesis

The scope of this thesis will be the C3 Curriculum and its need for a war game system to bring each of its students to an awareness of C3 problems in an operational environment. The SWRI's CAST will be analyzed as a potential system. Finally, a feasibility study will be conducted to see if the NPS can support such a system.

2. Methodology

Technical research material was gathered from the SWRI and the Naval Training Systems Center, Orlando, FL to help in evaluating modifications to the system to fit the NPS's needs. Information was also collected from the 2d Marine Division operations office at Camp Lejeune, NC, and the Marine Corps Research and Development Command at Quantico, VA for system validation as a C3 trainer. The needs of the C3 Curriculum as it relates to requiring each student to have a certain level of operational awareness was explored.

C. SUMMARY

This thesis will provide the basic description and capabilities of the CAST system. More importantly, this thesis will describe the modifications necessary to ensure the CAST is a suitable training aid for future C3 students.

II. WAR GAMING

A. WAR GAMING IN THE UNITED STATES ARMED FORCES

Military officers, unlike other professional people, cannot practice their profession, war, except in time of war. Consequently, throughout a great deal of history the military has developed or has sponsored and supported the development of methods and techniques that will permit them to practice their profession in time of peace. One such technique is based on the simulation of war and is known as "war gaming."[Ref 2:p.1-1]

1. Simulation

A simulation is an operating representation of selected features of real-world or hypothetical events and processes. It is conducted in accordance with known or assumed procedures and data, and with the aid of methods and equipment ranging from the simplest to the most sophisticated.[Ref 2:p.1-1]

Simulation provides the means for gaining experience and for making and correcting errors without paying the real-world penalties. It offers opportunities to test proposed modifications in a system or process, to study organizations and structures not yet in being, to probe past, present, and future events, and to utilize forces that are difficult or

impossible to mobilize. Simulation is of value as an education device and as a heuristic device. One of its major forms, employed for both purposes, is the war game.[Ref 2:p.1-2]

2. War Games

Both in and out of the military services, training or testing exercises and maneuvers with or without real forces and weapons and conducted under varying degrees of field conditions are often referred to as war games. Traditionally, however, the term is employed to describe conflict situations in which the operations are imaginary rather than real and when all of the forces, weapons, areas and interactions are simulated. The first war game conducted in 1824 was a theoretical conflict between imaginary forces on a map-like playing surface. Indeed, an early Naval War College definition called war games, "exercises in the area of war, either land or sea, worked out upon maps or tables with apparatus designed and constructed to simulate, as nearly as possible, real conditions."[Ref 2:p.1-2] More recently defined, a war game is a simulation, in accordance with predetermined rules, data, and procedures, of selected aspects of a conflict situation. It is an artificial conflict to afford a practice field for the acquirement of skill and experience in the conduct or direction of war, and an

experimental and trial ground for the testing of strategic and tactical plans.[Ref 2:p.1-3]

Depending upon the available equipment and reason for play, a war game may employ any one or a combination of three basic methods of simulation: manual, computer, and machine. The manual method uses people with such tools as game boards, maps, measuring devices, tables, and graphs. The computer method employs general purpose digital computers. Machine simulations are conducted on equipment such as the Navy Electronic Warfare Simulator which is designed especially for war gaming. However, regardless of the equipment and techniques, every game is conducted in accordance with a set of rules and procedures. These are known as the "rules of the game," or the "model of the game."[Ref 2:p.1-4]

In many war games a variety of situations and interactions are simulated: a landing operation, naval forces engaging air units, submarine versus antisubmarine forces, and so on. Each requires its own rules or specialized model. In addition to these representations of the various operational and battle processes, procedures or special models are usually required to control functions that are not features of the real-world events being simulated, but that are necessary to carry out the simulation. This may include special attrition models or logistics simulations. So, a war game model is the set of all the procedures and rules required for the control and conduct of a war game.[Ref 2:p.1-6] The model of a war

game provides for the types of forces, the level or levels of command decision, and the modes of support, communication, and interactions which have been selected from the real-world, and includes a description or explanation of the processes needed to carry out the simulation. The model accepts inputs such as the number of forces, logistics factors, and so on, and produces outputs in the form of planes splashed, ships sunk, loss of effectiveness of units, and objectives obtained.[Ref 2:p.1-7]

In the war game the nature of the problems, the reliability of the data, the player-game relation, and the rules of play all introduce experimental errors that are difficult if not impossible to separate from the resulting output data. The war game need not have any direct human factors in it but such factors are almost unavoidable when the format of the game includes teams and referees making decisions in the course of play. The exchange of information coupled with the learning processes of the players cannot be avoided. The war game often undergoes rules changes as a part of its development, and, since the initial set of rules rarely covers all the cases that arise in play, rule modification is inevitable. Finally, war games are usually developed as they are played, because the learning curve present when the human element is introduced is quite steep. This leads to problems surfacing with the war game. These problems are corrected during the development stage.[Ref 2:p.1-30]

3. Disadvantages of War Games as True Simulators

Players often assume roles in the game they never assumed in real life. They are presented with a situation that will reveal their degrees of ignorance or competence with respect to the problem under study. The rules of play can stifle a player's originality or cause undue confusion because they are incomplete or vaguely stated. The influence of players' attitudes toward their roles in the game will influence decisions and consequently the results. In the course of playing subsequent replications the player's learning process will again influence his decision perhaps in a different way from the influence of learning during the play of a single game.[Ref 3:p.72] Most of the difficulty with war gaming, as it relates to simulating a true battle, lies in the unmeasurable spheres of human decisions that are in part required as a reaction to a military situation and to certain assumptions concerning enemy choices of action.[Ref 3:p.74]

B. WAR GAMING AT NPS

The following is a description of machine war games currently used at NPS.

1. RESA - Research, Evaluation, and Systems Analysis

RESA, formerly the Interim Battle Tactical Trainer (IBGTT), is a research and evaluation tool for systems analysis and testing associated with naval operations, including command, control, and communications systems. It is

also used for operation plan evaluation, command and control training support for senior officers, Joint C3 interoperability assessment, and warfare systems architecture analysis. RESA requires a heavy human element in order to be played. The players must be proficient in naval and air tactics. They must also be able to make decisions based on game generated intelligence, situational computer screens, and communicated information from other players. The war game focuses on Naval Battle Group/Force operations in the theater context. Simulated weather conditions in 24 geographic regions affect flight operations, weapons and sensor performance. Four acoustic environment conditions affect sonar performance. The system can handle all naval conventional areas, limited mine warfare and amphibious operations, and joint air defense and strike operations missions. RESA models Battle Group and Force at the level of ships, submarines, and aircraft and associated weapons, sensors, and C3I Systems. It includes models of shore bases and wide-area surveillance systems and surveillance satellites that may support battle force operations. Models that record and link communications also affect the perceived tactical situation. Logistics support from ships and shore bases is also modeled. The game is two-sided, symmetric and reactive with a neutral side that may be introduced. No land warfare or terrain is modeled in RESA. The RESA output comes in the form of minute-by-minute tactical situation in geographic plot

format and 30 menus of alphanumeric data pertinent to the situation, postgame analysis printouts of all force positions, detections, engagements, and communications occurring during the scenario.[Ref 4] RESA is located in the secure warlab at NPS.

2. TACWAR

TACWAR, the Tactical Warfare Simulator, is primarily a closed research and evaluation tool. No human interaction is necessary. TACWAR encompasses most combat missions, both air and ground, within the theater with a 12-hour time step for conventional analysis. The model does not explicitly represent SOF, C3I, and CS/CSSD. Ground entity level varies from company-size subunits up to more prevalent division-size units. Ground weapons are modeled at an aggregated level by type. Aircraft are generally modeled by aircraft type. The attrition process for ground results in a killer-victim scoreboard. For air, individual aircraft losses and sortie loss rates are tabulated by mission category.[Ref 4] TACWAR is located in the TRAC Monterey facility at NPS.

3. JTLS - Joint Theater Level Simulation

JTLS is used primarily to analyze theater-level operations plans. It is designed to serve as both an operations support and a force capability tool to assess the value of different mixes of forces or resources. The model has also been used as an exercise driver. Similar to RESA,

JTLS requires heavy human player interaction. The model can simulate land, air, and limited naval operations with full intelligence and logistics play possible. Graphics utilization is available on JTLS video disks to include: the Caribbean Basin, Southwest Asia, Central America, Europe, Korea, and Japan. Video images can also be displayed on Sun Workstations. Unit databases have been compiled for Korea, Central America, Europe, and Southwest Asia. The environment of the game is hex-based with all terrain features both man-made and natural depicted. Weather and time of day are also modeled. Conventional air, ground and naval joint and combined forces can be modeled. Ground attrition is based on Lanchester coefficients as modified by the environment and terrain. Losses are assessed against units on a database-defined period. Naval attrition occurs based on how susceptible the ship is to being hit versus the number of hits taken. Air attrition is assessed by probability of kill with output as individual aircraft kills. The wargame produces printouts of movement, attrition, intelligence, logistics data, and unit status.[Ref 4] JTLS is located in the secure warlab at NPS.

4. JANUS (T)

JANUS (T) is a combat developments tool. It is an interactive, near-real-time model developed to explore the relationships of combat and tactical processes. Players make

tactical and doctrinal decisions, deploy forces, develop scenarios, and make and execute plans. This is accomplished in the planning phase only. The game can accommodate any locale, depending upon data availability. Joint and combined battalion and brigade operations are the largest conducted. Normally, small unit tactics are exercised. Operations are conducted on three-dimensional terrain with various terrain features represented in daytime, night time, or under reduced visibility conditions. Weather data is also modeled. Virtually all weapons found on current or proposed battlefields can be portrayed. The individual system is the lowest entity modeled. Any battlefield condition or troop configuration can be modeled. The game produces a hardcopy output of game statistics, artillery summaries, direct fire reports, range analyses, detection tables, and killer-victim scoreboards. The game is also capable of graphical replay and rerun.[Ref 4] JANUS(T) is located in the TRAC Monterey facility at NPS.

These four war games aid the user in being more tactically proficient in an operational scenario. However, the war games do not employ a simulated real-world communications system to help the user close the loop to the C3 problems associated with combat operations.

C. SUMMARY

Background on war gaming in the military, and the war games available at NPS has been covered for a better understanding of how the CAST trainer fits into the world of war games.

At NPS, the C3 curriculum uses the four war games for a variety of reasons. The games are used to introduce the student to military war games and their peculiarities, or the students are asked to gather data for analysis while playing the games. However, there is no war game in place at NPS that aids the student in realizing the command, control, and communications problems in an operational scenario.

III. COMBINED ARMS STAFF TRAINER (CAST)

A. MISSION

Simulation training systems have evolved in complexity to the point where they can simulate realistically the stress and unexpected events that upset the military decision-making process. CAST offers a realistic, integrated environment in which to rehearse combined arms planning and execution while reinforcing tactical maneuver proficiency. Before 1988 the opportunity to train in a combined arms environment was limited to Marine Corps units participating in Combined Arms Exercises (CAX) at the Marine Corps Air Ground Combat Center (MCAGCC), 29 Palms, CA. Since 1988 CAST exercises have formed an integral part of the CAX cycle. With the arrival of CAST at other locations around the Marine Corps Fleet Marine Force (FMF) units ranging in size from Battalion to Marine Expeditionary Force (MEF) have the same ability to practice the teamwork required to command, control, and coordinate the use of supporting arms in the field. A CAST training exercise may be tailored to identify areas of individual weakness in prerequisite knowledge, to satisfy the need to train particular skills, or to obtain maximum training benefit in a limited period of time.[Ref 5:p.1]

B. SCOPE

Each CAST is installed in a dedicated building that accommodates personnel from various command and staff levels of either a Marine Expeditionary Brigade (MEB) or Marine Expeditionary Force (MEF). These include maneuver units, indirect fire organizations (artillery, mortars, and naval gunfire ships), air support control agencies, helicopter and fixed-wing pilots, and Combat Service Support Elements (CSSEs). Collectively, the personnel who train with the CAST are called the "exercise unit." Training of the exercise unit is facilitated and controlled by an "instructor-controller group."[Ref 5:p.2] This group operates the CAST and controls the simulation of the friendly and opposing forces.

The CAST provides the exercise unit with the means to promote interaction among levels of command and the various control agencies that normally would be found in a tactical environment. The CAST exercises the detailed planning and coordination required to develop, execute, and validate a particular scheme of maneuver and its plan of fire support.

The heart of the CAST device is a computer network that simulates the actions of combat and combat support elements. The computer network drives a laser target designation system that marks friendly and opposing forces (OPFOR) ordnance impacts on a three-dimensional terrain board model. (friendly lasers are green, OPFOR are red) The process used in the CAST requires each echelon of command and control that conducts

fire support operations to communicate and to execute properly its respective functional role before the requested fires show a laser spot on the model terrain surface.[Ref 5:p.2]

Along with the instructor-controllers, commanders and staffs of front-line units and pilots have a direct view of the terrain board model that displays force distributions and ordnance impacts. Other command and control personnel are isolated in rooms called exercise cells. These cells are linked to the front-line units through a simulated yet realistic and doctrinally correct radio network.[Ref 5:p.2] The communications system incorporates electronic warfare (EW) jamming capabilities.

CAST systems are located at: Kaneohe Bay, HI, Camp Lejeune, NC, Camp Pendleton, CA, and 29 Palms, CA, with proposed sites at Camp Butler, Okinawa, and Quantico, VA.

C. DESCRIPTION

Emphasized in the CAST are the detailed planning and coordination required to develop, execute, and validate a particular scheme of maneuver and its plan of fire support. Regardless of size, each CAST is comprised of seven systems:

- computer terminal network,
- fire marking system (FMS),
- terrain board system,
- communications system,

- video system,
- clock system, and
- public address system (PA).

These systems are briefly described below and illustrated in Figure 1.

1. Computer Terminal Network

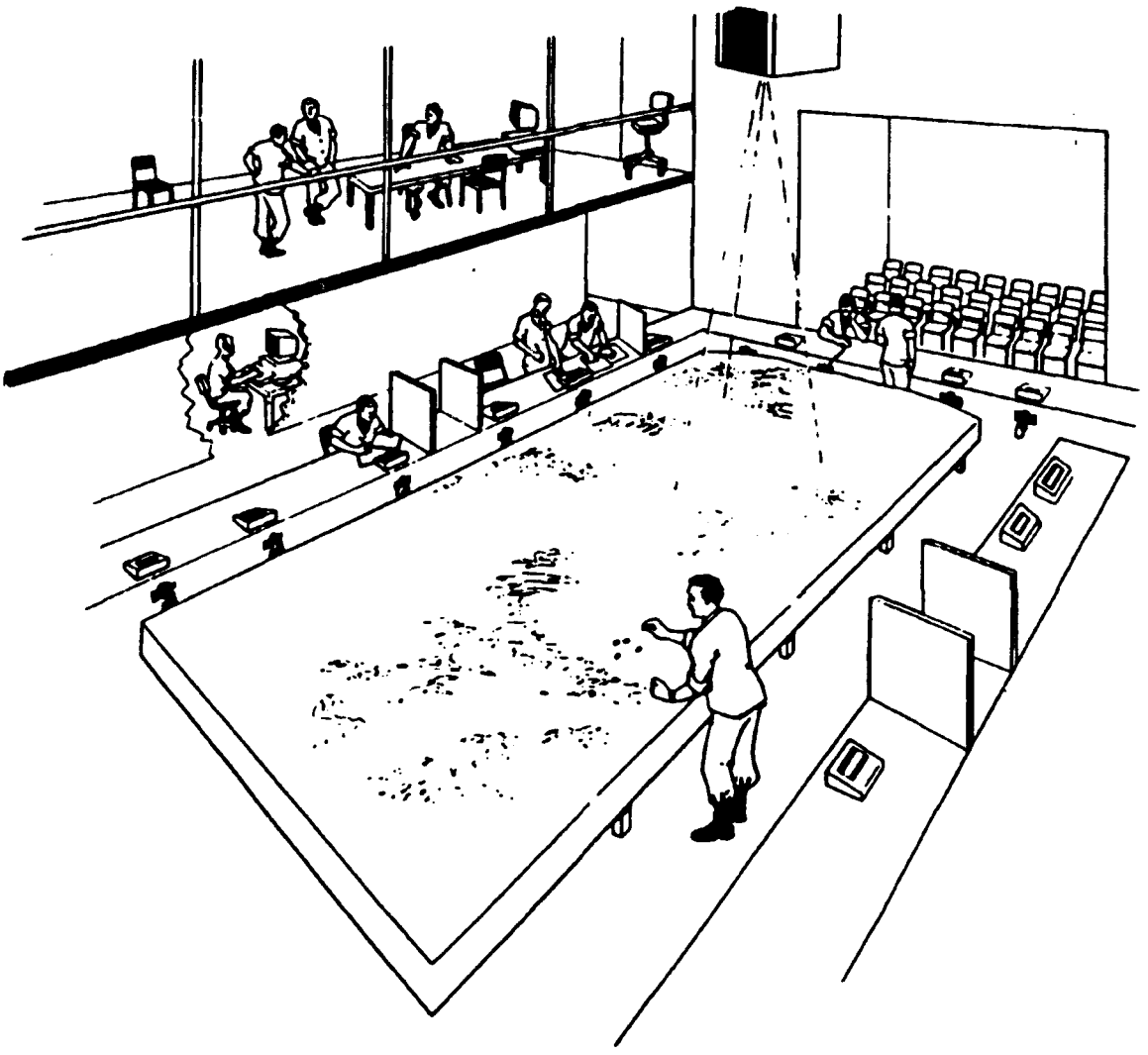
The network of computers comprises the heart of the CAST. This system performs the supporting arms actions of combat and combat support elements in various functional areas:

- amphibious task force commander,
- air command and control agencies,
- pilots,
- artillery fire direction,
- naval gunfire,
- EW,
- combat service support, and
- OPFOR.

These functional areas can either act alone or interact with each other in a complex combined arms scenario.[Ref 5:p.4]

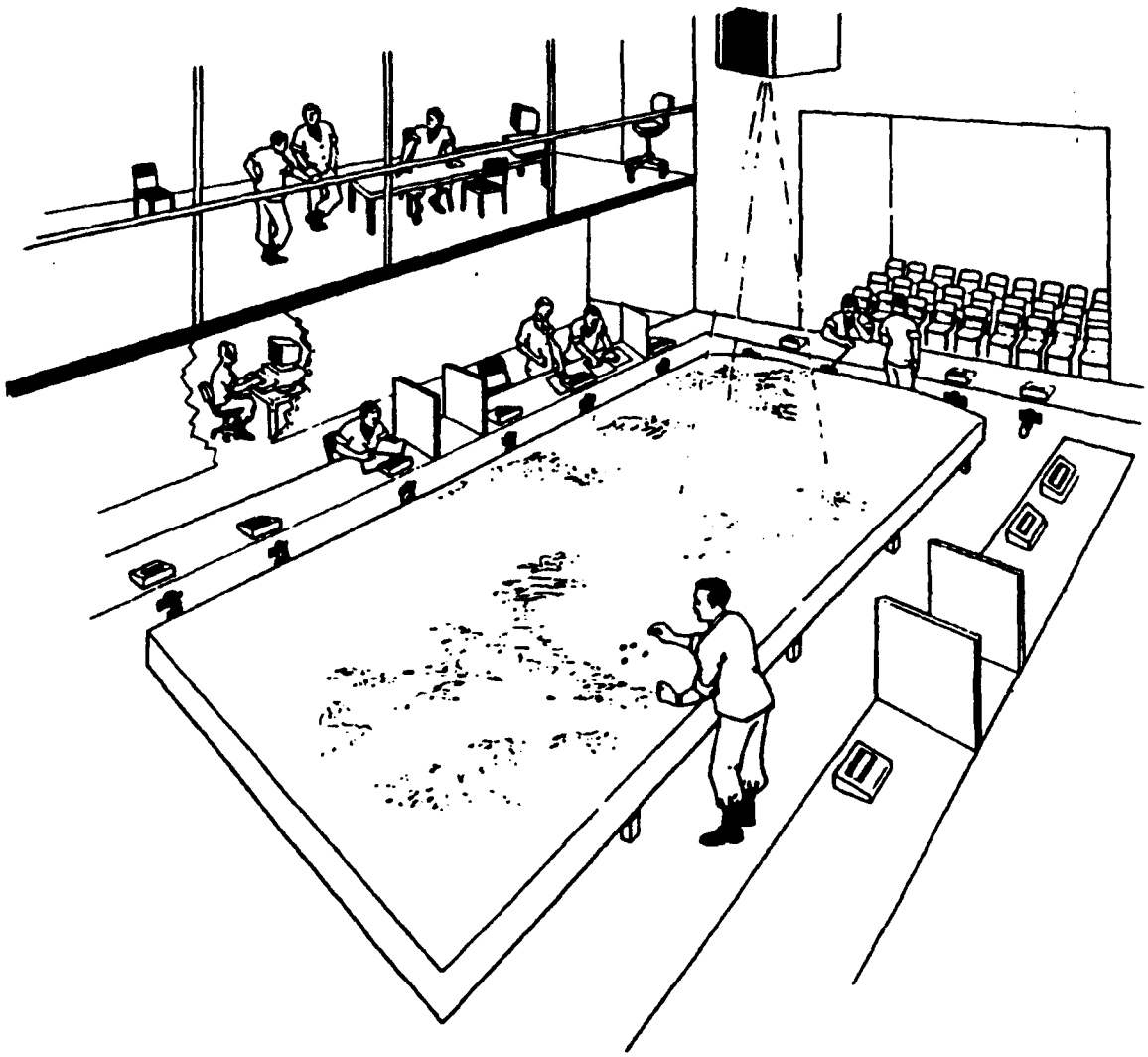
2. Fire Marking System

The FMS is a computer-controlled target designation system that uses low-power, eye-safe lasers to project



COMBINED ARMS STAFF TRAINER

Figure 1



COMBINED ARMS STAFF TRAINER

Figure 1

5. Video System

The video system includes a remotely controlled video camera mounted in the ceiling above the terrain board support structure. Four 26-inch color video monitors are located in the classroom area and provide real-time display from the video camera. The purpose of the system is to record video images of a CAST exercise to support a post-exercise critique.[Ref 5:p.5]

6. Clock System

Two-inch, digital LED-display system clocks are mounted in pairs throughout the CAST facility. One clock of each pair displays the exercise time, while the other displays Greenwich Mean Time.[Ref 5:p.5]

7. Public Address System

Consisting of speakers placed throughout the CAST facility, the PA system is used by the instructor-controller group to make administrative announcements.[Ref 5:p.5]

D. SYSTEM CAPABILITIES

The CAST enables the user to practice staff functions and individual procedures for the coordination and control of all supporting arms. The supporting arms functional capabilities contributed by the computer network are:

- exercise preparation, execution, and report generation;
- simulation of scheduled and unscheduled indirect methods of fire and air-delivered ordnance;

- simulation of primary and secondary mission types;
- simulation of standard target designation types;
- call-for-fire operations;
- worksheet operations;
- specification of up to 44 firing organizations, 60 ammunition types, 200 targets, and 50 worksheets of each type;
- split battery operations;
- identification of fire mission scheduling conflicts for friendly indirect fires;
- verification of range from firing organization to target;
- ammunition accounting by individual ammunition type and by organization; and
- exercise log files record all fire mission activities and warning messages issued to the user.

While each CAST device is supplied with only four sets of three-dimensional terrain boards, the CAST allows training to occur in most locations throughout the world on a flat-map playing surface. The CAST computer system and the FMS can adjust to flat maps of any scale up to 1:100,000.[Ref 5:p.6]

E. SYSTEM LIMITATIONS

The CAST is a staff trainer. It has no analytical capability. It cannot predict the outcome of tactical or strategic actions.

The communications system networks are hard-wired to each cell. Guard channels required for a cell's function are wired

to individual user positions. Exercise participants must sit at exact positions within specific CAST cells that match their assigned function.

The CAST does not provide packaged scenarios. The user must develop all scenarios/exercise materials used during a CAST exercise.

Specific system limitations [Ref 5:p.6] are:

- no operations in the North and South Polar regions of the globe;
- simultaneous aerial illumination of friendly and OPFOR 'active' fires is limited to 30 each;
- specific OPFOR organizations or locations are not defined. OPFOR has call-for-fire capabilities only;
- air missions distinguish between fixed-wing and helicopters, but they are not tied to individual organizations. The CAST also does not verify range to the target, identify scheduling conflicts, or perform ammunition accounting for air missions;
- although up to 60 ammunition types may be defined for use within the system, visual recognition is possible of only two ammunition types. High explosive appears as steady illumination, and white phosphorus is displayed as light pulsing at a two-hertz rate; and
- activation of rerun or replay options is limited to once per exercise phase of less than 24 hours.

Although these limitations may hinder a typical operational unit in the Fleet Marine Force (FMF), the CAST's shortcomings will not be a detriment to its play at NPS.

F. MEASURES OF EFFECTIVENESS (MOEs)

1. Qualitative MOEs

The CAST is used to help combined arms staffs exercise their battle operations plan - a qualitative measure of effectiveness. In other words, the CAST will help the staff's realize the success or failure of their plan. Often, these battle staffs have not worked with each other, and are brought together for an exercise or contingency. They have mastered their individual warfighting skills in the areas of aviation, armor, fire support, infantry, combat service support, etc, but have not worked together as a team. It is unreasonable to assume that these warriors could come together, not having trained with each other, and be effective during the exercise or contingency. Exercising the operations plan on the CAST has proven to be invaluable to the battle staffs before it comes time to operate in the field. The staffs are more confident in their plan, having worked out the major problems that surfaced in the CAST.

2. Fiscal MOEs

In these days of budget cuts and force reductions, the Marine Corps cannot afford to spend the money it takes to send each of its operational units to 29 Palms to master live-fire combined arms. Any unit desiring to train at 29 Palms has available to it a wide variety of major end items. These include tanks, amphibious assault vehicles, HMMWV's and a

variety of support equipment. Although 29 Palms is very generous with its equipment, the training unit is required to bring everything else it needs to train with and survive in the desert for a three week exercise. The Marines require shelter, individual weapons, and personal gear. The units must continue to operate their administrative and maintenance shops, even though away from their parent bases. 29 Palms can not supply every end item needed by the unit, so most of the equipment must be flown in, or sent by rail or low-boy. The aviation assets must fly their entire units to 29 Palms and reestablish themselves. Fixed-wing and helicopter squadrons require a tremendous amount of supplies and equipment to stay flying. The amount of money required to train these units is quite extensive. The CAST ensures the taxpayer gets his monies worth out of the training units. The Marines come to 29 Palms confident of their abilities to get steel on target at the proper time. If not for the CAST system, more money and time would be required for the Marines to reach their proper level of proficiency. Many say that the individual young Marine does not benefit greatly from the CAX at 29 Palms. Some say that the money it takes to move these Marines could be reduced and better spent at the Marine's home base. It is argued that only the battle staffs and key players need to be involved in the CAX. This makes good fiscal sense, but what cannot be disputed is the amount of money the CAST saves the taxpayer by first training the Marines in a war game

environment before exercising their plan in the field. Perfecting the delivery of bombs on target is first accomplished with the CAST, rather than wasting expensive ammunition in an impact area. Hard figures on the savings CAST has realized have not been tabulated.

3. Operational MOEs

The backbone of the CAST's measures of effectiveness can be spelled out with six operational considerations. The acronym for these considerations is METT-TS-L. These stand for:

- M - Mission
- E - Enemy
- T - Terrain/weather
- T - Troops/fire support available
- TS - Time/space
- L - Logistics

Each of these considerations will be addressed to validate them as a measure of effectiveness.

a. Mission

The focus of any exercise is the mission, either the mission the unit sees for its training plan or the mission of defeating the enemy on the battlefield. The CAST helps realize both of these missions for the training unit. No unit can ever flawlessly execute its plan, human error sees to

that. The CAST can shift the odds of success to the user. With the use of after action reports on the exercises conducted at 29 Palms, it can be seen that through the years there has been a steady progression on the learning curve of combined arms live fire. Where once only a small portion of the training area was used on each exercise, now sweeping maneuvers are conducted that use virtually the entire area and its associated impact areas. Not too many years ago it would take a training unit three days to cover a ten mile corridor while destroying the simulated enemy units it encountered with live fire. Currently it is not unusual for a unit to cover 40 miles on a three day field problem while exercising live fire offensive and defensive scenarios. CAST has helped ensure that each has a head start with understanding the complexities of live fire on a grand scale. The training unit's mission is more timely and efficiently realized through the teaching aid of CAST.

b. Enemy

CAST has the ability to paint the enemy picture for the user in a way that no field exercise comes close. Through the use of enemy templated units, the user is able to graphically see what forces oppose him. Enemy unit counters are placed on the map or relief surface by the exercise control group the same way they would be doctrinally arrayed on an actual battlefield. The counters are tiny models of the

major weapon systems in the enemy unit. The exercise control group flips these counters over when they have been rendered ineffective by fire support, etc. The user may know everything there is to know about the enemy, but until he sees his opponent postured in front of him on the simulated battlefield, a true appreciation for what he is up against is not felt. The relief of the playing surface or the contours of a map are used to help mask enemy units from the friendly forces. OPFOR doctrine is strictly adhered to in order to paint the best picture of a likely enemy disposition. Similarly, an enemy unit on a movement to contact mission will be depicted in a doctrinal battle formation, traveling at the prescribed rate of movement. The CAST can illustrate the sometimes awesome size of forces the enemy can bring to bear. More importantly, CAST illustrates how much friendly firepower the enemy can take and how many forces he is willing to lose before he has to break off his attack. CAST provides the user a better understanding of enemy capabilities in live fire scenarios.

c. Terrain/Weather

With the use of relief surfaces and military tactical maps, CAST is effective in providing the user an understanding of how friendly and enemy forces can use terrain on the battlefield. In the desert, it is often difficult to hide your forces. By studying the CAST playing surface, one

can find the areas best suited to array forces without having to walk the ground before hand. Of course, there is no substitute for physically seeing a battlefield firsthand, but CAST is the next best thing. With increased experience on the trainer, the CAST can be an invaluable asset for the user's terrain appreciation. Although the CAST does not portray weather conditions, the effects of weather on the unit and on the terrain can be realized by using the CAST. Sometimes, shelter is essential for the unit when the weather turns on them. Establishing alternate plans in advance in the CAST can reduce the effects weather may have on the unit and increase the likelihood of a successful mission. In addition, the weather can effect the terrain on which the unit operates. In advance, it may be determined from a study conducted in the CAST that the storm system that is approaching may swell the river bed text to the area the unit is considering for a company strongpoint. It is then determined that an alternate sight would be more practical. Once again, the CAST has shown its effectiveness by helping the unit prepare for its battle scenario.

d. Troops/Fire Support Available

Another operational MOE is how the CAST helps the user array his forces on the ground. The total force structure includes organic, combat support, and combat service support assets. When the entire force is considered, it may

be extremely large and consequently difficult to manage. The troops and fire support available can be spread out on the CAST game board and arrayed as the commander sees fit. This action may possibly influence the commander to change his course of action. He may determine that his unit cannot cover the entire area of interest or that it is too massed for the terrain in question. Location as well as troop strength is important on the battlefield. It may be determined that an artillery unit needs to move closer to the forward edge of the battle area (FEBA) during offensive operations to be more effective against the enemy. Also, it may be determined that a service support unit must move to a safer, more centralized location to affect better resupply to a greater number of units. Whatever the case, if the ground forces have not previously been depicted in the battle area, CAST will help determine if the commander is effectively employing them.

e. Time/Space

Possibly the most important measure of effectiveness is the CAST's ability to exercise the commander's plan in time and space. The commander is able to simulate the precise timing necessary for coordinating combined arms. With the key players from each warfare specialty gathered around the playing surface, they are able to discuss exactly what the commander is looking for on many different types of engagements. The aviator is concerned that

SEAD fires arrive in time for him to make his final run on the target. The artillery fire direction officer wants to ensure his preparation fires go off at the proper time. The infantry commander wants to ensure his Marines know exactly how far they need to fight to reach their next objective. The logistics officer wants to know how far he may have to travel with his resupply trains the first day of the battle. The possibilities for CAST to help simplify the time/space equation are endless. Only recently, with the advent of long, sweeping maneuvers, has the time/space concept been seriously considered. The commander must know what to expect if his movement is slowed by any number of reasons or increased due to success on the battlefield. CAST helps ensure the difficult time/space problem is made easier.

f. Logistics

Without proper logistics considerations, a military operation will fail. With the increased maintenance requirements of our high-tech weapons, the weight the warfighting unit is expected to carry to support itself, the fuel needed to ensure the war machine keeps moving, and the support tail any unit needs to survive, logistics must be given top billing during the planning process. The CAST system helps the logistician by making him aware of the warfighter's plan. As he sees the plan unfold at the CAST, the logistics expert will be able to plan how he can best

support his unit. CAST can help ensure the difficult details of logistics are worked out before serious mistakes are made on the battlefield.

g. Summary

Several measures have helped to illustrate the effectiveness of the Marine Corps' Combined Arms Staff Trainer. Marines all over the world are concerned with perfecting the art of combined arms warfare. Combined arms training is the Corps' most challenging training. The expense involved can also be staggering. The CAST helps take a major bite out of the difficulty and expense of this important capability. With improved wargaming facilities, the Marine Corps can only improve its proficiency in this area. The CAST is an excellent start.

G. SUMMARY

CAST training exercises stress the use of the device in its designed role as a combined arms staff trainer. Combined arms exercises employ all of CAST's sophisticated systems. The CAST also may be used for training in other innovative ways. For example, CAST may be used without the FMS for CPXs where illumination of fires on the terrain table is not of particular interest or importance. In this way, the CAST could be used to plan a units road march or movement to contact when no supporting arms fires are anticipated.[Ref 5:p.12]

Examples of other types of training activities that may be conducted using selected assets of the CAST are:

- TACWAR war game exercises,
- STEELTHRUST war game exercises,
- forward observer training,
- naval gunfire spotter training,
- tactical air control party training, and
- helping students in the C3 curriculum at the Naval Postgraduate School become aware of C3 problems in an operational environment.

C3 students can benefit from the CAST system's ability to portray the complexities of combined arms operations. The students must have some understanding of tactical operations and inherent C3 problems in order to attempt to solve those problems. Suggesting fixes to C3 problems is the underlying purpose behind the C3 curriculum.

Despite its design restrictions, the CAST allows the user considerable operational sophistication. The principal design purpose of the CAST and its specific limitations aside, the ample capabilities built into the CAST limit its use largely only to the user's imagination.

In its designed role as a combined arms staff trainer the CAST will pay its biggest dividends to the Marine Corps. A weakness of the Marine Corps in preparing for combat is the training of a MAGTF's staff agencies and personnel to conduct

combined arms operations. The CAST provides a modern, realistic, and dynamic solution to that vexing problem.[Ref 5:p.12]

IV. CAST AT NPS

A. IMPLEMENTATION INTO THE C3 CURRICULUM

1. Introduction

It is important that the C3 student step off on the right foot when it comes to understanding the many C3 operational problems. Specifics will be discussed on how the CAST system can benefit the C3 Curriculum. A discussion of training on the CAST early in the curriculum will follow. Specific knowledge elements that can be fulfilled are explored. The skills the students need to possess, and an idea of how a typical training session will unfold is presented.

2. Early in Course Syllabus

As mentioned in the introduction, C3 students must quickly grasp an understanding of C3 problems in an operational scenario upon their arrival at NPS. The introductory C3 course (CC3000) provides a great deal of background in current C3 organization, systems, and practices. A basic framework for understanding C3 is provided. Case studies are used as well as lessons learned from crises, field exercises and war gaming.[Ref 6] However, the C3 student is not introduced to C3 problems in an operational sense. No war game or simulation is in place at NPS that gives the student

experience in this area. Hands-on application is required for the student to become proficient at recognizing operational C3 problems. The CAST system would be an invaluable asset to introduce the C3 student to operational command and control concerns during their introductory C3 course.

Additionally, the CAST system can help the C3 student master other knowledge elements or training objectives in the curriculum. These knowledge elements are specific items listed under the Educational Skill Requirements (ESRs) that constitute the curriculum objectives. A list of applicable knowledge elements, listed by core courses, can be found in the Appendix. The CAST can help satisfy the requirement that each student is familiar with such knowledge elements as functions of command, combat operations, concept of operations, and maneuver warfare. A complete listing of the C3 Curriculum knowledge elements can be found in Reference 7. From these knowledge elements the CAST will help the student understand the relationships of intelligence, air operations, fire support and maneuver, administration and logistics, and management information systems to the C3 function. Also, an understanding of the role of C3 tactical command and control systems in military operations, and the degradation of these systems when threatened by the enemy can be realized. The CAST system can help synthesize the command and control needs of the operators during crisis management. Finally, the student will be aided in understanding and applying the

concepts of operational analysis as it pertains to the decision making process. Although specific courses are dedicated to these knowledge elements/objectives, CAST will provide the student a real-world idea of integration and application of these concepts.

3. Training Requirements

As previously stated, many NPS students arrive for instruction with no experience in military operations. This would suggest a steep, very beneficial learning curve on the part of the student regarding the ground tactics associated with the CAST scenarios. Although some front-loaded instruction is required for system use, in-depth tactics instruction is not needed. The CAST system can be modified to use pre-programmed events tables that literally run the scenario for the user. With CAST's flexibility the user may be made to experience the command, control, and communications problems associated with a combat situation as it unfolds.

4. CAST Play

A typical C3 class consists of 35 students. The students would be divided into operational cells. With a group this size, a battalion size exercise is preferable. Specific cells include the:

- command element,
- air combat element,
- ground combat element,

- combat service support element,
- fire direction center,
- tactical air command center,
- forward air controller, and
- company/maneuver elements.

Three to five students would occupy each cell. The number of maneuver elements used in a particular scenario will determine the number of students needed in the company/maneuver element cell. Exercise unit tasks are specified in Reference 8, Appendix B. OPFOR play will be generated by the computer. Play begins once the players are divided into their cells, and understand their particular responsibilities. The scenario will be run by the CAST computer, with specific decision points generated to force a reaction from the players. The players' actions will be specific to their cell, and within the guidelines of combined arms doctrine. The players' actions may include ordering maneuvers, fire support, or air strikes. The actions will be relayed to the appropriate higher, adjacent, or subordinate headquarters via the communications system. The exercise controllers monitoring these transmissions enter the player action into the computer. OPFOR units are destroyed, destructive fires are adjusted, or friendly units are moved to comply with player actions. In addition, the players must react to any electronic warfare interference or jamming present on their cell's net. Their

transmission may be unimpeded, garbled, or cut off entirely. The cell must find the best way to ensure their transmission gets through. Play is halted when the training objective is reached.

B. MANIPULATION OF CAST SYSTEM

1. NPS Mini-cast

A full system CAST fills a dedicated building that accommodates all of the personnel to be trained in addition to the CAST training equipment. The fire marking system laser takes an 18 foot clear ceiling height. Extra storage space is required for terrain board storage. Raised platforms are needed for the exercise control group for access to the terrain boards.[Ref 9] CAST facilities are usually built from the ground up, but a dedicated building for the CAST facility at NPS is cost prohibitive. The current CAST system can be scaled down to suit NPS's needs in a way that eliminates the fire marking system and the terrain boards. In addition, the CAST's versatile communications system can easily adapt to this process.

a. No Lasers

The most expensive equipment associated with the CAST system is the fire marking system.[Ref 9] Its laser based technology, associated software, and dedicated computers account for a large portion of the systems expenditure. The laser marks provide a good visual aid for a large group

training in combined arms tactics. However, with the relatively small groups that will use the CAST at NPS, and the training objective that of exercising C3 problems, a marking system implemented on the individual cell's computer screens is adequate. Different color marks can be used for friendly and enemy units, and various fire support measures. Minimal software changes implemented by the SWRI Group are required to effect this adaptation.

b. No Terrain Board

The second most expensive item associated with the CAST facility is the terrain relief boards. The system usually includes 16 of these 4x8 foot three-dimensional boards.[Ref 9] They are cumbersome to move around and require a substantial area for storage. The Defense Mapping Agency (DMA) can provide two-dimensional terrain databases for many areas of the world. At NPS, tactical maps should be scanned into the computer's database and the terrain board eliminated. The tactical maps can be easily incorporated into the CAST computer system for projection onto the individual cell's computer screens. In addition, these terrain images can be displayed on centrally located big screen televisions or from an overhead projector onto an exercise playing table.

c. Communications System

The CAST's systems communications network is a stand-alone system. The phone system does not connect with

the individual user's computer, but is interconnected to the exercise controllers terminal for monitoring the play of the game. It is a simple, hard-wired telephone style communications system, with software driven electronic warfare (EW) capabilities. EW play can be introduced into the game by the controllers. The EW can come in the form of jamming the user's signal or presenting a tone that interrupts communications. The communications system can also record all transmissions for playback during end of exercise debriefs.

Although the hard-wired system is not obsolete, there is a plan to upgrade the CAST communications system to make it more flexible. This new system will replace the current hard-wired links between the cell terminals with coaxial cable. The individual cell communications boxes will be multiplexed for easy access to any cell in the exercise area. The new system will also provide more jamming capabilities. The major benefit to this new system will be the reduction in man-hours and maintenance required to rewire the communications to suit a particular exercise group. Finally, this new communications system will seem more like an actual field communications system to the user. This upgrade will become operational once a buyer agrees to pay for its initial engineering cost. It is not essential that NPS buy this multiplexed system.

In addition to the obvious cost saving to be had by implementing these changes to the current CAST architecture,

the system will be easier to use and less susceptible to maintenance problems. More importantly, however, the training benefit for the C3 student will increase with these changes.

2. ADA Program Language

A full system CAST requires 12 types of computers, each having a complicated, menu-driven user interface. A main design goal was an integrated menu system capable of processing approximately 400 required menus and minimizing code changes resulting from minor changes in menu content or format. An intercomputer communications design was developed and based on networked file sharing - the mailbox paradigm. The mailbox scheme uses the file ID concept. A software team of six people at the SWRI Group used object-oriented design to implement 100,000 lines of Ada. Ada was the language of choice due to the government's mandate to use it in Department of Defense programs.[Ref 10]

CAST was required to accommodate a robust set of capabilities, but there were no hard, real-time performance requirements. It was required, however, that the status of all active and pending friendly and opposing force fires be updated every 30 seconds. Implementation of the mailbox paradigm was successful even though message latency is noticeable in a heavily loaded training scenario. This approach to intercomputer communications could not be

successfully implemented in an application requiring more stringent real-time requirements for fires resolution.[Ref 10]

Ada can handle large amounts of code, as was the case for this project. Also, Ada has a good error rating and its integration time is low. The main disadvantage of using Ada is its unrealistic real-time event scheduling.

A fully operational CAST system can accommodate 400 trainees on 175 communications nets. According to the software design department at the SWRI Group, minor changes are required to scale the system down to accommodate a smaller training group as discussed earlier in this section. Software redesign by the SWRI Group will take little effort.

C. FACILITATING CAST

1. Location Alternatives

As discussed, the CAST at NPS will have reduced size and complexity, enabling it to be used in a variety of locations throughout the campus. The following are the possible facilities that could house the CAST system.

a. Warlab

The CAST is not a classified system, therefore it need not be located in a secure area. However, if the current warlab was to move to another location, the space it provides could house a modified CAST system.

b. Root Hall

Plans have been made to move the C3 Academic Group to the East end of Root Hall. Along with this move, a student computer lab will become operational in Root Hall. The vision is to provide a state-of-the-art laboratory facility which exposes students to the most current technology in networked systems. The lab is intended primarily as a platform for student research into the C3 issues involved in shared applications, distributed decision making, networked communications, file/database sharing, security, and modeling/simulations of C3 systems. The network will operate in a UNIX environment, run models and simulations, support communications and network models, run a host of programming languages to include Ada, and communicate with other networks for the exchange of information. The system should also have the ability to display mapping information as provided by DMA. Adequate power supply to the Root Hall facility must be considered.

The lab will employ a UNIX-based network of workstations. The current proposal is to use a Hewlett-Packard based Hughes Data Systems product called the Tactical Advanced Computer 3 or TAC-3.[Ref 11] TAC-3 represents the third generation of the Navy's program for the use of commercial computers to fulfill many of the requirements for shipboard and shore-based computing. The TAC-3 provides major graphics speed improvements for true color 3-D operations.

Its workstations offer maximum expandability. The workstations are more than adequate to run the CAST software. Also, this networked system could be used as a medium to operate the CAST's communication system.

c. Glasgow Basement

This area has no special utility at this time, and can be considered as large enough to house a modified CAST.

d. SCIF

Presently, the SCIF is quite crowded and in need of moving to a more substantial area. If this occurs, the SCIF would be an ideal location for a CAST system. The various spaces that make up the SCIF would accommodate the cells needed for the system.

e. C3 Systems Technology Lab

A C3 Systems Technology Lab is on the drawing board. The CAST system could be run as part of this lab or electronically connected to this lab as part of a larger network. The lab will be located near the new C3 academic spaces in Root Hall.

f. Summary

The best location for a modified CAST system is with the planned C3 academic spaces in Root Hall. The C3 Systems Technology Lab in conjunction with the CAST system would give the C3 student a state of the art facility for dealing with C3 issues.

2. Funding

a. Sponsor

Currently, the CAST project is sponsored by the Marine Corps. Although it is unlikely that the Corps will sponsor a CAST system for NPS, they may have an interest in the school's use as a central CAST think tank, as discussed in Section D of this chapter. More realistically, groups such as JCS (J-6), the Joint Warfare Center, the Naval Training Systems Command, or the separate CINCs would have a greater interest in such a project. It is beyond the scope of this thesis to identify and recommend which group or groups could sponsor a CAST system at NPS.

b. Dollars

Although a modified CAST system will not cost nearly the millions associated with a full scale system, there are some major cost to consider. The first users to incorporate the communications system's multiplex upgrade will incur its engineering cost. This expenditure could be as high as $500K. Obviously, the hard-wire communication system can be purchased at a fraction of the cost. The U. S. Government owns the rights to the source code for the CAST programs, therefore, software cost will be minimal even with expected modifications. Additionally, there will be the cost associated with providing the CAST system with tactical

terrain images, either from DMA support or scanning tactical maps to the database.

Without submitting a formal request for cost estimates for these CAST modifications to the SWRI Group, an accurate cost amount cannot be acquired. This action is beyond the scope of this thesis.

3. Lab Maintenance

The CAST maintenance concept calls for each device to be supported by a Contractor Operation and Maintenance Support (COMS) contract.[Ref 8:p.17] Thus technical support for operations and full maintenance of each CAST will come from a locally resident civilian contractor. The cost of the COMS will depend on system repair requirements. As a backup provision, in the event that COMS support becomes temporarily unavailable, an On-The-Job Training Handbook (OJTH) is available at each CAST device site. The OJTH contains maintenance procedures that will enable the user to become qualified CAST maintenance technicians. The OJTH is issued in two volumes - an instructor's and student's handbook. The OJTH makes substantial reference to the Planned Maintenance System (PMS) and the Operation and Maintenance Manual (O&MM). Both documents contain the actual maintenance tasks to be performed on the CAST. The PMS addresses all scheduled preventive maintenance tasks, while the O&MM contains fault

isolation and maintenance procedures for all unscheduled corrective maintenance tasks.

With a system of this complexity, maintaining its computers, associated software, and communications system is a major consideration. The SWRI Group goes through rigorous acceptance trials on the CAST system before its product leaves their facility. For this reason, the CAST's software is extremely reliable. No technical representative (tech rep) is required once the system is in place for the user. Typically, a system of this size will take two weeks to set up and test. Training sessions are offered and can be scheduled throughout the year once acceptance by the user is completed. For any hardware problems, local contractor maintenance can be utilized when needed.

The SWRI Group stands by its product. In addition, the elimination of stand-by technicians and maintenance personnel means a significant reduction in cost to the user.

D. CAST USAGE

1. Academic Uses

Although the primary users of the CAST system will be C3 students, the system is flexible enough to handle a variety of others. Students outside of the C3 curriculum may desire to use the system for thesis projects, and the faculty at NPS may find it advantageous to conduct research utilizing the

CAST system. The system need not be used once or twice a year for C3 students exclusively.

2. NPS as a Central CAST Think Tank

The CAST system is versatile and expandable. Its uses are limitless. Although the Marine Corps is the primary sponsor of this project, no centralized military support facility is in place to act as a watch dog for CAST's reconfigurations or scenarios. NPS is centrally located to the six CAST systems that are currently operational with the Marine Corps. The schools conference facilities, joint military atmosphere, and available brain power make it an ideal location as a CAST support facility.

a. Configuration Control Meetings

With the CAST constantly evolving and improving, meeting with system designers, software engineers and system users is useful. Configuration control meetings are required to document these proceedings. The Marines using the CAST system concern themselves with training on the systems, not how to improve CAST. Marine units train on the CAST and move on to the next training opportunity with little concern for CAST improvements. Concerned students and faculty at NPS, in conjunction with the manufacturer, could focus their efforts on keeping the system up to date with current technology, and improving the systems effectiveness. NPS has numerous spaces available for lectures, conference activities and system

demonstrations. NPS would be an ideal location for configuration control meetings and associated support activities for the CAST.

b. Haven for CAST Scenarios

The CAST's terrain relief boards require large storage areas. Therefore, a CAST system is limited in the number of areas of the world it can expose to a training unit. This also limits the scenarios with which to train. With DMA database support, the number of battle locations and scenarios available for use by CAST will be limitless. A central location for scenario generation, storage, and support is required to eliminate duplication and placing the burden of scenario generation on the training unit. NPS could double as a scenario haven, creating easy access to scenarios for conference meetings or training units at the six CAST facilities.

E. SUMMARY

The current CAST system is flexible and adaptive. It can be tailored to fit the needs of the C3 student. Adequate facilities are available at NPS to house a modified CAST system. In addition to its use by the C3 Academic Group, a CAST system at NPS could be used for campus-wide research, with NPS facilities providing a think tank atmosphere for all CAST systems currently fielded.

V. CONCLUSION

The current CAST system as fielded by the Marine Corps has been described. The need for a training system to exercise C3 problems for the C3 student at NPS is obvious. The SWRI Group has agreed that the CAST system can be manipulated to support the C3 Curriculum. With major changes in the CAST's hardware configuration and other changes in its software design, the CAST can suit the needs of NPS. With these changes to the present CAST system there will be a significant reduction in the installation and operational cost accrued by the sponsor of CAST at NPS.

Much work remains on the specifics of software design for operational scenarios, graphics displays, and cell configuration. Various facilities are available at NPS to house a modified CAST system, with the most likely being the spaces planned for use by the C3 Curriculum in Root Hall. In conjunction with the proposed C3 Systems Technology Lab, the introduction of the CAST system will provide an exciting learning environment for future C3 students. In addition, NPS has the facilities available to become a centralized think tank for CAST reconfiguration meetings and scenario generation.

APPENDIX

C3 KNOWLEDGE ELEMENTS RELATED TO CAST LISTED BY CORE COURSES

CC 3000

- Functions of Command
- Process of Command and Control
- Combat Operations
- Maneuver Warfare
- Tactical Command and Control

CC 3001

- Combat Theory for C3
- Tactical Influences on C3

CC 4001

- Top-level Warfare Requirements

CC 4002

- Concept of Operations

NS 3252

- Principles of War
- Chain of Command

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